Design for Manufacturing (DFM): Defining the processes

It is important for designers to understand the basic processes entailed in the manufacture of an electronic assembly and their relationship to cost and quality. Developers that understand and include DFM in their development process will dramatically lower manufacturing costs, reduce production cycle time and increase product reliability.

A given assembly may go through any of the following processes dependent upon its composition and the product requirements for that assembly:

Pre-processing:
- Component prep: pre-forming, programming, lead trimming, labeling, etc.
- Pre-assembly of components: fasten heat sink to component, clip pin out, etc.
- Pre-bake: baking of components or PCBs to mitigate potential effects of resident moisture
- Etch cuts
- Ionic contamination testing: verification of PCB cleanliness prior to assembly

Primary surface mount assembly:
- Screen print solder paste
- Machine place
- Hand place
- Re-flow solder
- Clean

Secondary surface mount assembly:
- Screen print solder paste
- Machine place
- Hand place
- Re-flow solder
- Clean

Secondary surface mount assembly to fasten components for wave solder:
- Screen print or dispense epoxy
- Machine place
- Hand place
- Oven cure epoxy

Primary through-hole assembly (mass soldering):
- Machine or manually insert components
- Wave solder
- Clean

Secondary through-hole assembly:
- Machine or manually insert components
- Hand solder each connection
- Clean

Secondary components:
- Hand place and hand solder components that cannot withstand primary process
- Hand place and hand solder components that are located to prevent primary processing

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Planned rework:

- Component modifications
- ECO wiring

Press fit:

- Press fit connectors
- Press fit pins or test points

De-panelize:

- Cut out circuits by hand
- Cut out circuits with tooling
- Cut out circuits by machine

Hardware and labels:

- Assemble screws, nuts, washers, spacers, standoffs, etc.
- Labeling or marking

Inspection:

- Visual inspection
- Automated optical inspection
- X-ray

Test:

- Hi pot test
- In-circuit test
- Functional test
- Burn in
- Verification test

When we examine the potential processes a particular assembly may go through, we see that certain processes are unavoidable while others are elective--meaning that the design does not necessarily dictate a certain type of test or inspection method, but are requirements of the user or manufacturer.

Automated processes are repeatable, have much lower defect rates and expose the component and assembly to less heat and less handling. Manual processes increase cycle times, are more likely to require rework and increase the cost of manufacture without adding value to the product.

Proper component selection and board layout are the two primary factors that will reduce assembly cost, decrease cycle time and enhance long-term reliability. Selecting components that are compatible to the process are essential; selecting components that take advantage of the processing enhances quality, throughput and cost reduction. Good examples of component selection to enhance the process are choosing marked components when AOI is employed and the biased selection of components to the primary process.

By designing to reduce the number of processes, avoiding manual processes whenever possible and selecting components that are compatible with the assembly process, the total quality of the product can be greatly enhanced.

Lets take, for an example, two assemblies that are identical electrically with the only difference being component selection and layout. In this example, we will assume it is a RoHS compliant assembly.

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Assembly 1:

The top side of the assembly has both surface mount and through-hole components. Surface mount pads are as close as 2mm to any edge of the circuit. There are through-hole connectors that overhang one edge of the circuit below the plane of the top layer.

The bottom side of the assembly has only surface mount. There are tantalum capacitors and chip components ranging from 0603 to 1812 and two SOICs. The orientation of these components is random.

Ideally, we would like to process the assembly as follows:

1. Screen print solder paste on the top side of assembly.
2. Place SMT on the top side of assembly.
3. Re-flow the top side of assembly.
4. Screen print epoxy on bottom side.
5. Place SMT on bottom side.
6. Cure epoxy.
7. Insert through-hole components on top side.
8. Wave solder.

This would involve the lowest number of process steps and avoid manual processes. Unfortunately in this case, we can't do this because of component selection and location on the assembly.

Problem #1: Surface mount pads on top side violate keep-out for conveyor clearance.
Effect on processing: Apertures in stencil must be masked and parts loaded and soldered by hand.

Problem #2: Through-hole connectors overhang the edge.
Effect on processing: The assembly may require tooling or masking prior to wave solder depending on the configuration of the wave solder machine used.

Problem #3: Improper orientation of components on bottom side.
Effect on processing: Since the components are not all properly oriented along the axis of transit through the wave solder, there will be skips, shorts and voids if assembly is wave soldered.

Problem #4: Variation in freeboard height of the components on the bottom side.
Effect on processing: Must be dispensed, not screened.

Problem #5: Poor selection of components on the bottom side.
Effect on processing: Even if the SOICs can tolerate a RoHS wave (not all can), the 1812s are not recommended for wave solder. The 1812 components (and SOICs if they cannot be waved) will be placed and soldered by hand, or a wave solder fixture is required and all SMT components on the bottom side will be re-flowed.

Conclusion: Manual process steps or tooling can be added to overall process to compensate for design but they do not add value, only cost and variation to the process.

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Assembly 2:

1: The top side of the assembly has both surface mount pads and through-hole connectors. Surface mount pads are at least 5mm to any edge of the circuit. There are through-hole connectors that overhang the circuit flush with the top plane of the assembly on one edge of the circuit.

2: The bottom side of the assembly has only surface mount pads. There are chip components ranging from 0603 to 1206. The orientation of these components is facing along the axis of wave transfer.

Conclusion: These few changes will allow us to use our ideal process and eliminate the need for tooling or manual processing.

Summary: With most assemblies, the difference between achieving ideal and having to compensate with added cost is not a great variation in the design. If the PCB designer is aware of the impact to cost and quality, the basic decisions made when initial component placement is generated are likely to have a long-term positive impact on the overall product quality. Every effort should be made to educate PCB designers, and design reviews should include DFM steps early in the design and layout process. Too often, DFM is inserted at the end of a design project if it is done at all. Once the design has been accomplished, project schedules and other demands tend to overtake the DFM concerns and the result is years of additional cost with no added value, or even diminished value to the product integrity.

If you would like a free DFM analysis or would like New Age Technologies to provide a free on-site seminar on this topic at you facility – just send an email to D@NewAgeEMS.com with your request and we will be happy to accommodate you.

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